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ENGAGING AND MOTIVATING UNDERGRADUATE SCIENCE STUDENTS IN A WRITING WORKSHOP DESIGNED TO ACHIEVE INFORMATION LITERACY AND PROFESSIONAL LEVEL COMPETENCE

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A biology workshop is described that encourages science undergraduate students to engage in multi-step processes that lead to professional-level report writing. Students enter this one-semester course with an attitude that is usually refractory to both reading and writing. In consultation with the Indiana University Campus-Wide Writing Program, the course was developed to encourage student engagement. The participation of a librarian as co-instructor provides an opportunity to integrate information literacy principles into course assignments. "Writing equals thinking" represents the core cultural value, and the course is structured to motivate students to become engaged in major writing tasks. Students are empowered to take ownership of various significant aspects of the course, including selecting the several main themes for a variety of common scientific literature types. The course is taught in a biology department that emphasizes modern molecular biology in its curriculum, so topics such as "cancer," "microbial drug resistance," or "the non-coding genome" have been chosen in recent years.

Information literacy-based exercises provide students with a professional-level conceptual framework and skill set to effectively access and use relevant literature sources. Included in those exercises are lessons designed to help students evaluate the validity and authority of individual literature sources. Peer review of preliminary outlines and first drafts of manuscripts connects students to the common themes and fosters a collaborative classroom culture. Various exercises such as "writing an effective title" promote professional-level aspirations. The end product of each semester is a set of 4 spiral-bound volumes that includes individual assignments such as review articles and research proposals. The knowledge that they can append their own writings to resumes for job searches or submit their work to a campus-wide writing competition provides additional motivation for students.

Keywords: Science writing workshop, Information literacy, Scientific writing exercises.

Introduction

The importance of reading and writing skills in science is often contradicted by student attitudes that motivate them to avoid paths of study that require those skill sets. Science students frequently consider reading both overly time-consuming and boring (e.g., Moore, 1993). Science students are also usually classic "hands-on" learners who would much rather be working in the laboratory or designing experiments than engaging in reading and writing tasks. Those attitudes,

which surveys reveal are common among science students (Manske, 2007), contradict the widely recognized notion among professional scientists that communication through reading and writing of data, theories, and experimental technology continues to gain in importance.

Indeed, science students assiduously avoid enrolling in literature-based courses or philosophy courses. Science students often fear that those courses may require myriad reading assignments or writing long term papers that convey no immediate practical application. Those courses usually involve substantial amounts of verbal reasoning. Students who aspire to become scientists prefer courses that involve abstract thinking and quantitative reasoning, though only if those courses require minimal verbal articulation of thinking and reasoning. This creates a learning gap for science students between the disciplinary knowledge and practice and the ability to communicate effectively via writing in their own discipline. Nevertheless, if students can develop the impression that their writing is engaging them with someone else, they are more likely to become enthusiastic and less likely to express boredom (Brookes, 2010).

Goals of this Writing Workshop

Four main goals provide opportunities for engaging students in intense writing experiences and offer possibilities for monitoring student achievement.

1. Enhance the ability of students to employ scientific thought processes. This is accomplished when the scientist-professor models authentic thought processes and typical scientific reasoning modes during classroom discussion.
2. Empower students to believe that they are capable of writing meaningful scientific prose. This is achieved by calling attention during classroom discussion to examples of their writing that are especially meritorious.
3. Instill information literacy skills and concepts in undergraduate students so that they can research beyond textbooks to collect, analyze, interpret, and synthesize the information contained in professional-level information sources.
4. Provide students with tangible rewards for accomplishment. Such rewards include the "portfolio review/grading procedure" and spiral-bound books containing their major writing assignments (described below).

The Role of Information Literacy Initiatives in the Biology Curriculum at Indiana University

Information literacy refers to students' abilities to determine their need for, access, evaluate, and use information (ACRL, 2000). While some of these skills are often taught in entry-level general education courses, there is little evidence that transfer occurs in a meaningful way once students encounter information-intensive courses in the disciplines of their chosen majors. Early introduction to writing that is followed by an increasingly complex application of information literacy skills in advanced science courses does, however, improve a student's chances of achieving professional-level competence by graduation time.

Fortunately, information literacy concepts complement science-related disciplines particularly well. There are numerous parallels, for example, between the language that describes information literacy standards and the National Science Education Content Standards (Manuel, 2004). Also, when information literacy standards are viewed as steps in a linear or

cyclical process, they bear a strong resemblance to the scientific research process itself. This resemblance has provided a basis for many information literacy initiatives pursued by the Indiana University Biology program.

A major challenge is the determination of the level of information literacy skills that can be effectively taught to students as they progress through their degree program. For example, beginning biology students should not be expected to use primary literature in the same way that seniors do. Nevertheless, it can be expected that students at all levels are capable of acquiring information literacy skills in a stepwise fashion. Furthermore, those skills complement and enhance existing discipline- and course-specific learning outcomes (Shannon & Winterman, 2012; Winterman, 2009). Indeed, assessment of the effectiveness of integration has shown not only an increase in basic information literacy skills related to access and use of resources, but also enhancement in writing abilities and student self-perceptions of what constitutes authentic scientific thinking and effective scientific writing (Winterman, Donovan, & Slough, 2011). The following key points summarize recent experiences at the Indiana University Biology Department:

- Information literacy is best learned when integrated into science courses, rather than learned as an independent skill set.
- Concepts that comprise information literacy complement the sequential thinking that characterizes molecular biology research.
- Integration of information literacy into science courses enhances student understanding of the way scientists think.

Case Study: L322 - Writing Workshop in the Logic and Rhetoric of Molecular Biology

This 15-week course is co-taught by the authors, a veteran scientist and a professional librarian. It integrates a formal information literacy agenda with in-depth analyses of molecular biological phenomena. The course meets twice per week for 75 minutes per session. Enrollment is limited to 25 students, usually seniors and occasionally juniors. Surveys carried out by the authors at the start of the course reveal that approx. 75% of L322 enrollees "hate writing", and have postponed their writing course requirement until their last year of college. Although they have the option of enrolling in a humanities-based writing course to fulfill their writing requirement for graduation, they elect this course out of fear that those other courses will entail larger reading assignments, as well as longer term papers.

Information literacy principles are introduced as a cyclical process in which students engage in exercises and activities that involve increased complexity of information harvesting and evaluation. At first, students develop a strong foundation of information structure and communication channels in molecular biology. Then they are expected to develop skills that allow them to synthesize information, offer reflective analysis, and ultimately propose original ideas and solutions for problems or questions they have identified from their literature searches. As students engage in these higher-order levels of critical thinking, the authors model scientific thought processes and provide examples of effective scientific prose.

Comparison of Expository Science & Technology Writing with Traditional Laboratory Reports

The traditional laboratory report provides most science students with their first introduction to "scientific writing." It usually is formatted to emphasize the use of the scientific method as its core concept. Its focal point is, of course, the data derived from laboratory experiments. The goal of the typical undergraduate lab report is to use the writing exercise as a way to learn about the discipline of science. Thus, the designation *Writing To Learn* (WTL) has been given to this approach of using typical lab report assignments in undergraduate courses (Moskovitz & Kellogg, 2011). The WTL approach offers both advantages and disadvantages, as briefly explained by Goggin (2011).

Most of the writing assignments described herein are less formulaic than the typical lab report, which includes Introduction, Methods, Results, and Discussion sections. Instead, broad content, theories, and conceptual frameworks are general features of L322 expository scientific writing. The aim is to have students mimic the style of authentic review articles, research proposals, and essays. Since professional level prose that includes some rhetorical content is the goal of L322, the writing which comprises the major portion of this course has often been designated *Writing As Professionalization* (WAP) (Moskovitz & Kellogg, 2011).

Rhetoric as a Feature of L322 Prose

Often, hypotheses and/or theories are presented and evaluated in expository science writings. Since the art of persuasion (rhetoric) is frequently employed in professional prose, L322 students are encouraged to develop their rhetorical skills in their major assignments. For example, their titles should contain, whenever possible, key words which reveal the significance of the body of the text. As well, the ending section ought to affirm the importance of the information contained therein. These features are especially valid for the research proposal students write in this course.

Class Logo Emphasizes the Relationship between Thinking and Writing as a Process

A logo has been designed to reflect the emphases associated with this approach to scientific writing:

Figure 1. The L322 class logo emphasizes that writing promotes critical thinking.

It affirms that writing assignments represent process-oriented rather than product-oriented endeavors (discussed below). Clear thinking is illustrated as enhancing the meaning of prose. As students become more skilled at writing, their laboratory-derived data and their conceptual ideas gain strength and prominence. This notion has often been promoted by other writing instructors (e.g., Woodford, 1967).

Are Undergraduate Students Ready for Professional Level Writing Assignments?

It is generally recognized that students will become more motivated to engage seriously in completing a writing assignment if the nature of the assignment involves an authentic intellectual endeavor (Manning & Hanewell, 2010). The professional level writing assignments in the writing workshop described herein include the following intellectual characteristics: construction of knowledge; building of contextual frameworks; and effective communication of overall ideas.

As well, empowering students by providing opportunities for them to take ownership of important aspects of L322 contributes to high student motivation, as described below.

Finally, some L322 students have explained that it is important to them that their completed assignments do not end up in the trash bin. Knowing that their reports and essays will be spiral bound into a book and eventually viewed by various biology faculty and staff or entered into competitions (see below) provides added incentive for motivation and engagement.

Key Exercises: Process Versus Product Orientation

The "process" of writing major assignments (e.g., research proposals—see below) is emphasized in the sense that writing assignments, since they represent continuous thinking (Figure 1), can be

expected to generate evolving thoughts. Writing is therefore explained as representing an "indeterminate" endeavor.

Topic choice for assignments is important for motivating L322 students. Allowing them to participate in topic choice serves as a key motivator. Students are encouraged to choose topics that they find either personally interesting or challenging. As a consequence, students develop a feeling of ownership of specific assignments. They are subsequently required to prepare either an outline or concept map for peer review as a starting point. Occasionally, those outlines/concept maps are tacked to the classroom wall, and the entire class is encouraged to view and critique them (Figure 2).

The final product is of course graded by the instructors and that grade is entered into the class register. However, by the time the final product has been graded, the writing process has undergone several phases: Choice of topic, literature review, outline/concept map (peer reviewed), first draft (peer edited), review by graduate students in the Campus Writing Tutorial Services (optional), and quick preview by the instructors. Thus, students are continuously engaged in one or another step in the writing process over the three weeks typically devoted to a single major assignment. All of that engagement occurs simultaneously with day-to-day worksheet assignments related to general aspects of professional-level writing (e.g., how to write an effective title).

Figure 2. Concept maps pasted on the wall of the classroom for peer review.

Students are encouraged to collaborate by explaining their ideas to their peers. In this example maps diagram relationships between various components of eukaryotic non-coding DNA.

Collaborative learning plays an important role in L322. Students are grouped into teams of 4-5 for routine class discussions as well as immersing themselves in editing the outlines and manuscripts of their fellow students. Reviewing writing progress with peers provides yet another way in which students maintain focus and remain engaged in the classroom experience.

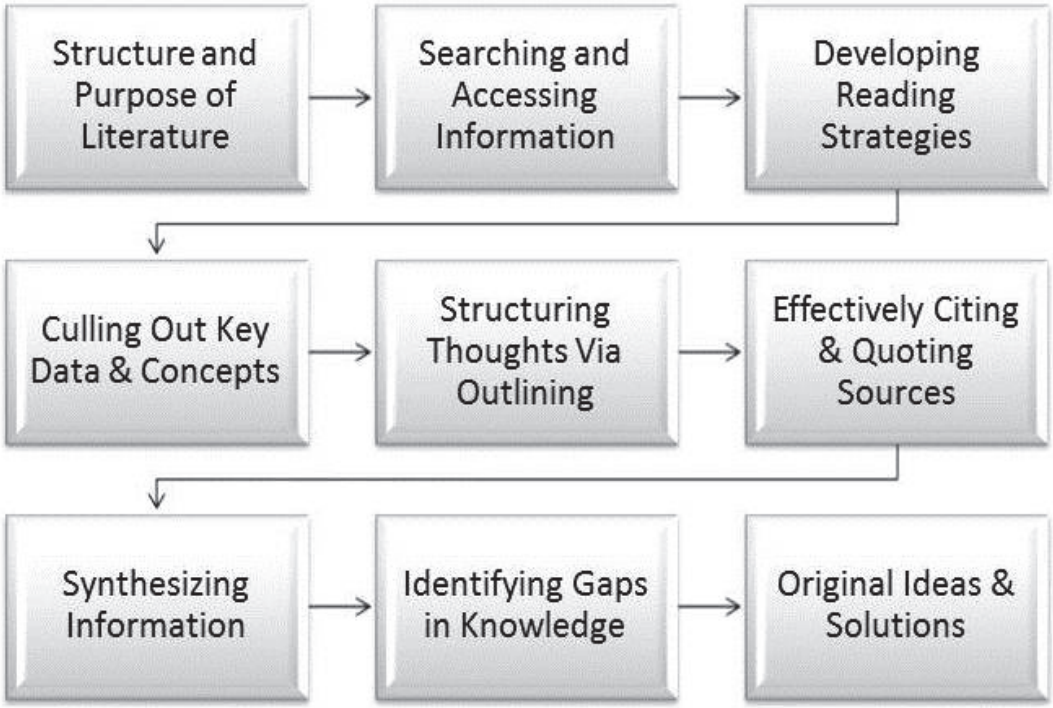
A description of major writing assignments is provided below:

Assignment	*Target Skill Development*
Essays	• self-analysis (e.g., Procrastination is Enemy #1) • identification of personal strengths and weaknesses
Review Article	• examine strategically selected literature sources • identify connections and opposing viewpoints • critically analyze approaches and directions
Research Proposal*	• perform "exhaustive" literature searches • identify gaps in current knowledge • recommend research to address gaps
Book Chapter	• use a broad variety of literature sources • broaden focus to be comprehensive • coordinate with peers to make a cohesive collection

*Research proposals regularly represent students' favorite assignment!

Organization of Thoughts During the Writing Process

Outlining is essentially the visual, spatial, and mental organization of thoughts. Since writing and thinking are inseparable in L322, well-organized thoughts lead to better writing. Further evidence of these relationships can be found in the unfortunate circumstances where a student has not given adequate attention to one or more of the sequential steps; insufficient exploration and topic development lead to incomplete outlines, incomplete thoughts, and a poorly executed final product. The following diagram organizes a successful journey through the steps of the major L322 writing projects:



Motivating Science Students to Engage and Overachieve

As mentioned previously, a key factor for motivating students is empowering them to have a significant say in the organization of L322. As well, by providing students with substantial support services, they engage more fully in the course. The strategy taken by the instructors represents the so-called "autonomy-supportive style", which contrasts with the "controlling style of teaching" often employed in college writing courses. Our style yields enhanced student interest and subsequent elevated achievement, as predicted by Reeve et al. (2004) and Reeve and Jang (2006).

The instructors of the course recognize that most students enter this course with a negative attitude towards writing. Thus, early on instructors are always quick to applaud (sometimes literally) and congratulate even the smallest increment of improvement exhibited during routine class exercises and discussions. The goal of the instructors at the start of the semester is to gain the trust of students, so that they actually believe that diligent efforts will be rewarded with high course grades.

Later in the semester the instructors attempt to fulfill the typical student's yearning for self-expression by providing examples from the scientific literature that illustrate how writing can communicate ideas more deeply and reliably than can the spoken or electronically-telegraphed word.

Below are listed several of the ways in which the instructors motivate students to succeed in L322:

- Permit students to elect 2 co-captains (one male, one female) to interface between the instructors and students regarding workload, topics, etc.

- Schedule due dates of major assignments so they do not conflict with major exams in other courses.
- Encourage students to share information, rather than compete by hoarding key insights into specific assignments. Collaborative learning is encouraged.
- Establish a course grading procedure that permits all students to be eligible for a high final grade.
- Provide support services such as computer-equipped classrooms for information literacy class exercises.
- Offer instructor office appointments for previewing major assignments.
- Provide students with extra credit for peer reviewing assignments of fellow students.
- Permit students to choose many of the topics that comprise major writing assignments.
- Occasionally focus class daily assignments on recent research breakthroughs, such as genomics, embryonal stem cell advancements, etc.
- Model the scientific thought processes which lead to important research discoveries as a way to help students mature as they gravitate towards careers in science.
- Encourage students to believe that *writing* about science facilitates *understanding* science, especially complex phenomena such as the "regulation of gene expression."
- Repeatedly explain to students that investigating ideas through writing leads to innovative and creative thought processes.
- Allow students to design covers and choose layouts for each of the four books produced each semester. This endeavor encourages creative and organized thinking.

Evidence of Success

L322 writing often exceeds the quality that one might expect from first-year graduate students. Students frequently report a sense of great accomplishment and empowerment during portfolio reviews. Preliminary formal assessments have been done to measure student learning and attitudes in L322, specifically regarding information literacy skills (Winterman, et al., 2011). Pre- and post-test assessment results are summarized as follows:

- Improved ability to choose appropriate information resources
- Improved search strategy development (essential for "exhaustive searching")
- Increased self-perception of ability to "read and understand" literature
- Increased self-perception of ability to "express scientific ideas in writing"

Other assessment results from student feedback, portfolio reviews, etc., confirm that students feel empowered by the L322 system. They also frequently explain that they are motivated by writing about topics that "matter" to them. Those observations demonstrate that combining information literacy principles with writing in molecular biology creates a uniquely effective teaching and learning model. Both the enhancement of student learning and the acquisition of professional level writing skills are experienced by L322 students.

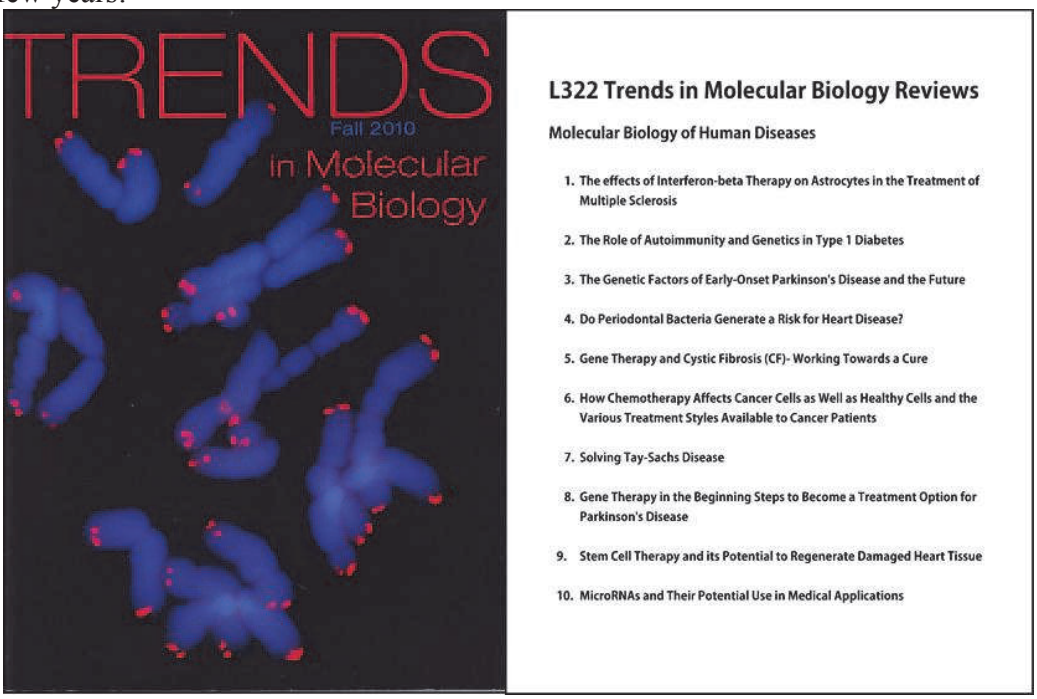
One of the many advantages of the process-intensive approach is the opportunity for instructors to monitor intellectual activity as students progress through their writing tasks. Each step builds upon the previous one and increases in complexity. Likewise, the quality of the final product is substantially increased by the attention given to quality workmanship in the steps leading up to that final product. For example, when the choice of topic is left to the students,

they are more motivated to explore multiple facets of that topic in depth. Thorough exploration leads to outlines with greater substance and structure.

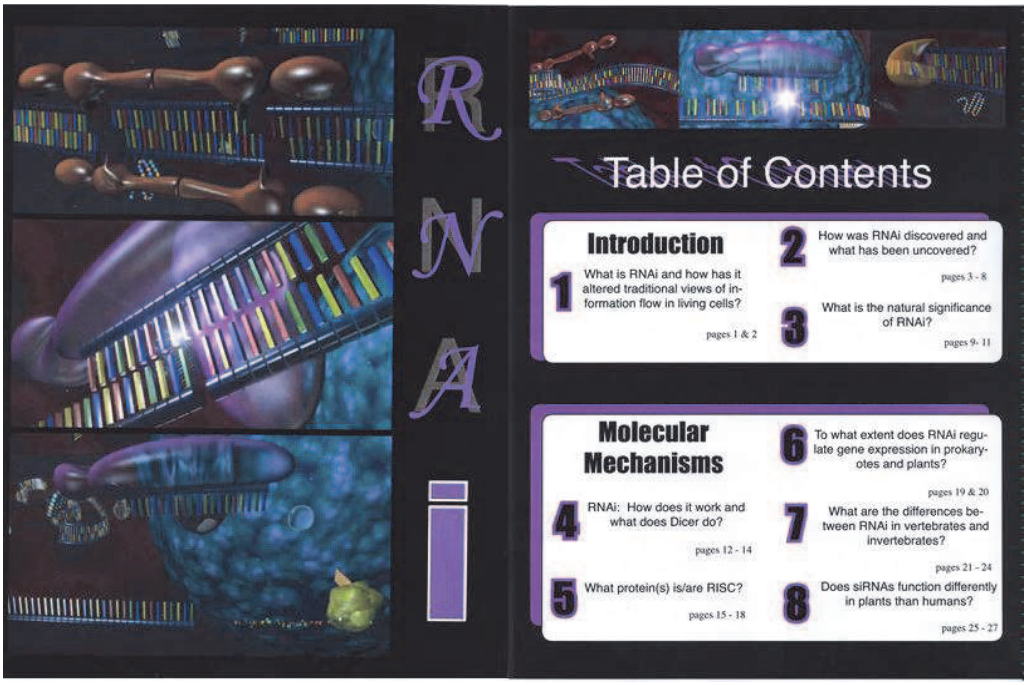
Another indicator of success in L322 is the manner in which students use their writing assignments to strengthen job resumes or applications to research programs. L322 is recognized in the Department of Biology as one of the most successful upper-level courses. Students are frequently encouraged to enroll in this course by their mentors and advisors. Enrollment in the course always fills quickly.

A particularly significant indicator of success is the recognition some students' work receives outside of the Department of Biology. The College of Arts and Sciences at Indiana University offers writing awards to undergraduates across campus. In the last 3 years, L322 entries have been awarded 2 first prizes and 2 honorable mentions, a remarkable accomplishment considering the size of the College and the number of eligible students.

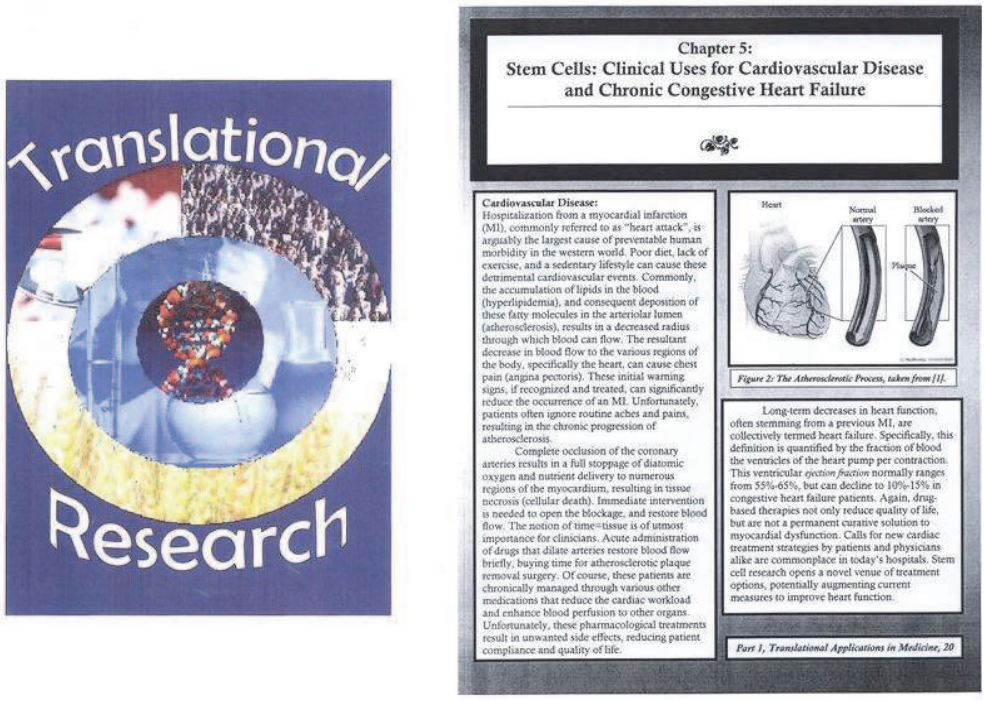
Shown below are examples of some of the most visually appealing L322 volumes produced over the last few years:



Compilation of review articles with partial table of contents.



Compilation of book chapters with partial table of contents.



Compilation of book chapters with example of content.

Modelling the Enterprise of Scientific Research in the Classroom

Explanations of the background and history behind various important discoveries in molecular biology (e.g., structure of DNA, human genome sequence, antibiotic resistance, etc.) fascinate

students. Exposure to descriptions of the intellectual rigor involved in Nobel Prize-level discoveries as well as to the concomitant personal features (e.g., competition between research groups to achieve the first complete sequence of the human genome) enhances student interest and subsequent engagement in writing exercises. The instructors weave into those explanations examples of how writing is an integral part of the process of scientific discovery.

The goal of this feature of L322 is to help students understand how molecular biologists think rather than to simply learn how to recite what biologists know. By writing chapters for the set of books mentioned above, students are encouraged to adopt the attitude that "science is a way of knowing" (Moore, 1993). They are thereby encouraged to think ahead and reflect on what the next question or hypothesis in science might be, based on their own current writing and thinking.

Collaborative learning activities at each step of the writing process simulate the deliberations that a scientific team might employ when writing a review of their discoveries for a professional journal. Preparing a review of historical aspects of a research project might, for example, begin with a topical outline. Writing a review article to serve as a stepping stone to conceptualizing future experiments, in contrast, might begin with a concept map (see Figure 2).

Exercises as Day-to-Day Classroom Activities

The several major writing assignments are spaced more or less evenly throughout the 15-week semester. While students are engaged in the writing process for those major reports and essays, each regular class period focuses on a worksheet assignment provided to students at the end of the previous class. Included in those exercises are lessons designed to help students evaluate the validity and authority of individual literature sources. In addition, peer reviews of preliminary outlines and first drafts of manuscripts connect students to common themes in molecular biology and foster a collaborative classroom culture. The exercises are varied. Several examples of worksheet activities are provided below:

Goal	*Format*
Improve outlining skill	Outlines for writing assignments are shared and critiqued by fellow students.
Enhance editing skill	Photocopies of examples of both well and poorly written reports/essays drawn from scientific journals are critiqued by students and compared in collaborative learning groups.
Learn to prepare a concept diagram	Topics that are comprised of interconnections between either data or theories are studied and key features diagrammed with connecting lines or overlapping circles.
Learn to write a science journalism essay (e.g., newspaper)	Examples of current newspaper reports of science discoveries are reviewed and critiqued.
Develop skill for writing a title	Sample journal reports are reviewed and more effective (i.e., more rhetorical) titles are devised.

Providing students with a diverse menu of daily exercises maintains their interest for the entire semester in improving their writing skills. Students eventually agree that critiquing a published journal article, or devising novel and persuasive (rhetorical) titles requires them to adopt the role of a professional scientist. They are thereby less likely to become bored and disinterested when the daily class routine is varied.

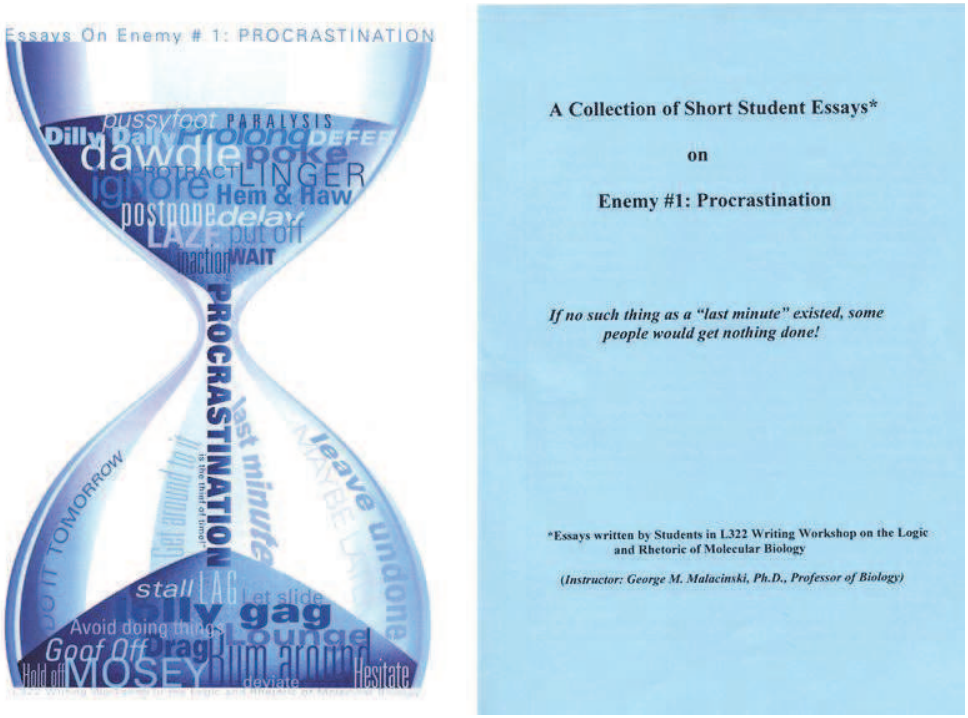
Enemy Number I: Procrastination

Surveys of present and past students enrolled in L322 have revealed that, with very few exceptions, each student tends to procrastinate when it comes to accomplishing major writing assignments. Thus, the "process" orientation employed in this workshop provides a mechanism for thwarting that tendency to procrastinate. As the due date for a major assignment approaches, the various steps in the writing process are monitored during collaborative learning classroom discussions. Students as well as instructors therefore recognize the progress they are making towards complying with the due date (late submissions are down-graded ½ grade for each class period they are submitted late). Nevertheless, like most college students, dealing with deadlines represents a challenge that these science students are often skilled at circumventing, postponing, or denying until the last possible moment.

One strategy employed in L322 is to provide an opportunity for students to confront their personal tendencies to procrastinate. One of the books each class writes is entitled "Procrastination: Enemy #1" and consists of a collection of personal essays concerning their own procrastination behavior. Each essay is required to include a section on anti-procrastination techniques. Samples of titles and themes of personal essays on the subject of L322 student procrastination are provided below:

Title of Essay	*Theme*
Procrastination and Collegiate Academic Life	Procrastination is an integral part of human behavior.
Is Procrastination Inevitable?	It becomes a habit.
My Worst Enemy	Fear of failure encourages it.
The Ugly Truth About Procrastination	It is triggered by neurological viewpoints.
The Art of Waiting Until the Very Last Moment	A progression (cycle of procrastination) leads to postponement.

An example of a "procrastination book" is shown below:



Compilation of procrastination essays with title page.

Portfolio Grading Procedure

In order to confirm to students that L322 writing should be viewed as a process, a grading scheme that emphasizes improvement over the course of the semester is employed. That is, grades are recorded as the assignments are submitted. Then, at approximately the 2/3 mark of the semester, each student provides to the instructors a brief self-assessment of his/her progress in preparation for a one-on-one review of the student's portfolio of graded assignments. The student's performance (steady, improving, or declining) is discussed and for those students who have demonstrated steady improvement, the more recent grades are emphasized when final course grades are calculated.

Class attendance is considered mandatory, and a record is taken at each class period. After two absences, a student's final course grade is lowered one-half grade. Attendance is therefore usually complete, with very few students exceeding the 2-absence limit.

Variations on this approach have been employed by others in order to emphasize to students that writing is a process that provides opportunities for personal growth (Metzger, 2010). Rather than individual grades representing a "hit-or-miss" endeavor, students are usually motivated to improve their writing abilities knowing that maturity is a desired outcome of this workshop.

Counterforces Impede Implementation of Professional-Style Writing Exercises in the Typical Undergraduate Curriculum

The Labor-Intensive Nature of Teaching a Writing Course

The single greatest difficulty with writing exercises at large research-oriented universities such as Indiana University (42,000 students on the Bloomington [residential] campus) is associated with recruiting faculty to teach science writing courses. They frequently claim that it takes them away from their research laboratories. Career advancement in science/technology departments is ordinarily based on number of original research publications and the monetary value of outside research grants or patents.

The shortcuts to organizing the typical classroom experience such as the use of PowerPoint presentations, films, or discussion of textbook reading assignments are not easily adapted to teaching a writing course. Rather, the writing professor needs to devote significant time outside class to grading large numbers of (sometimes) long writing assignments. Thus, enthusiasm seldom exists on the part of the science professor to engage in teaching writing courses (Brillhart & Debs, 1981).

Faculty Development Programs Often Fail to Generate Interest and Expertise

Various protocols for faculty development programs are certainly available (DaRosa, Simpson, Marcdante, & Fleming, 2010). Nevertheless, participation in faculty development programs that focus on "enhancing the writing abilities of undergraduate science/technology majors" fail to draw high interest from the professors who actually interact with students in the classroom (Camblin & Steger, 2000). In addition, during times of financial turbulence the first task of management is to maintain administrative structure and faculty numbers (Drucker, 1980). Funding for faculty development is therefore jeopardized by the financial pressure most universities around the world face in the present uncertain economic times.

Frustration with Students Who Lack Adequate Preparation

Faculty are often not prepared to deal with students who begin a class with poor written grammar skills, deficits in verbal reasoning, poor penmanship, and lack of motivation.

The typical faculty responses include the following: (1) high schools have done a poor job preparing students; (2) students should enroll in remedial writing course before taking my class; and (3) this is a science class, not a writing class!

Students' General Ambivalence Towards Formal Pedagogical Exercises

Faculty often complain that students' interests in a collegiate experience are often connected to university social life, rather than academic pursuits (Arum & Roksa, 2011). Students frequently seek to enjoy the benefits of a full collegiate experience that is focused as much on social life as on academic pursuits. Their goal in many instances is to earn high grades in their courses with as little effort as possible. Faculty are therefore not particularly motivated to devote time to reading their lengthy term papers.

This difficult situation is exacerbated by the increasing frequency with which students plagiarize sections of major writing assignments. Dealing with plagiarism involves first

detecting it and then reporting it to appropriate university administrative staff, and finally, deciding on appropriate penalties.

Writing Courses in Science and Technology Tend to Draw Small Numbers of Students

Science students have a tendency to search through both the science curriculum as well as the larger university curriculum and enroll in those courses that have a reputation for minimal writing assignments. "Shopping around" leads to low enrollments in rigorous science writing courses, and subsequent stress on departmental faculty budgets.

Future Direction

In this "information age" it is of course necessary that all science undergraduates develop proficient information literacy skills. One approach to dealing with some of the counterforces mentioned above would involve developing internet-based sets of exercises for information literacy. Such an approach, if carefully designed, might provide an opportunity to append such exercises to several courses—at different levels (e.g., sophomore, junior, and senior)—and thereby diminish some of the labor-intense aspects of science writing courses. Regardless of delivery method, any science curriculum could benefit from including more information literacy-based writing exercises that introduce students to concepts and skills that increase in complexity and sophistication throughout the course of the curriculum.

Concluding Remarks

The following quote is taken from an L322 (2011) student's self-assessment for his/her portfolio review with the instructors.

> *"The assignments I liked best were the review paper and the research proposal. I feel that they significantly improved my ability to read scientific articles, to synthesize information and to express my argument in a concise manner. My finished review article gave me a sensation of immense satisfaction and confidence in my writing and research skills. I began to feel like a true scientist. Being removed from my comfort zone has revealed to me that I am capable of undertaking unfamiliar and seemingly overwhelming tasks. With this newfound confidence in my abilities, I plan to take more risks in all aspects of my academic, professional and writing careers."*

Other students have made similar comments, thereby validating the strategy of the writing workshop described herein.

Many university students now operate in a two-tiered communication system. An increasingly significant tier is represented by social media (e.g., various electronic social connection systems). The traditional tier, which appears to be continually struggling to remain relevant to university students, is comprised of serious academic/professional report and essay writing. This latter tier continues to gain in sophistication at the professional level. The possibility therefore exists that a gap will develop between student affinity for social media and workplace professional-level prose.

Thus, it is the aim of the present authors to encourage writing instructors to adopt some of the components of the Indiana University's L322 Writing Workshop in the Logic and Rhetoric of

Molecular Biology described herein. By engaging and motivating undergraduate science students as described above, those students likely will "begin to feel like a true scientist," and act like one by enhancing their ability to develop and express ideas through formal prose.

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